

## CLAIMS:

1. A combination fuel cell and ion pump comprising:  
an electrochemical cell comprising an anode inlet for receiving fuel, an anode outlet for exhausting fuel, a cathode inlet for receiving oxidant, a cathode outlet for exhausting oxidant and at least one of purified oxygen and purified hydrogen, and a first electrical connector and a second electrical connector; and  
a controller for applying an electrical load to said first and said second electrical connectors wherein said electrochemical cell acts as a fuel cell to generate electricity, and applying an electrical potential to said first and said second electrical connectors wherein said electrochemical cell acts as at least one of a hydrogen pump to purify hydrogen and an oxygen pump to purify oxygen.
2. The combination fuel cell and ion pump of claim 1 further comprising a first valve attached to said cathode inlet for controlling air to said electrochemical cell and a second valve attached to said cathode outlet for exhausting oxidant and purified hydrogen from said electrochemical cell.
3. The combination fuel cell and ion pump of claim 2 wherein said second valve is operable to exhaust oxidant from said electrochemical cell in a first direction and exhaust purified hydrogen from said electrochemical cell in a second direction different from said first direction.
4. The combination fuel cell and ion pump of claim 2 wherein said electrochemical cell and said controller are operable to generate electricity and to purify hydrogen.

5. The combination fuel cell and ion pump of claim 1 wherein the electrochemical cell comprises a plurality of electrochemical cells.
6. The combination fuel cell and ion pump of claim 1 wherein the electrochemical cell comprises a PEM electrochemical cell.
7. The combination fuel cell and ion pump of claim 1 further comprising a first valve attached to said anode inlet for controlling fuel to said electrochemical cell and a second valve attached to said cathode outlet for exhausting at least one of oxidant and purified oxygen from said electrochemical cell.
8. The combination fuel cell and ion pump of claim 7 wherein said second valve is operable to exhaust oxidant from said electrochemical cell in a first direction and exhaust purified oxygen from said electrochemical cell in a second direction different from said first direction.
9. The combination fuel cell and ion pump of claim 1 wherein the electrochemical cell comprises a solid oxide electrochemical cell.
10. A combination fuel cell and hydrogen pump comprising:
  - a first electrochemical cell comprising an anode inlet for receiving fuel, an anode outlet for exhausting fuel, a cathode inlet for receiving oxidant, a cathode outlet for exhausting oxidant, a purified hydrogen outlet for discharging purified hydrogen, and a first electrical connector and a second electrical connector;
  - a second electrochemical cell comprising an anode inlet for receiving fuel, an anode outlet for exhausting fuel, a cathode inlet for receiving oxidant, a cathode outlet for exhausting at least one of oxidant and purified hydrogen, and a first electrical connector and a second electrical connector; and

a valve disposed between said first electrochemical cell and said second electrochemical cell, said valve comprising a first passageway for transferring fuel from said first electrochemical cell to said second electrochemical cell, a second passageway for transferring exhaust fuel from said second electrochemical cell to said first electrochemical cell, a third passageway for controlling transfer of oxidant from said first electrochemical cell to said second electrochemical cell, a fourth passageway for controlling transfer of exhaust oxidant from said second electrochemical cell to said first electrochemical cell, and a fifth passageway for controlling transfer of purified hydrogen from said second electrochemical cell to said purified hydrogen outlet.

11. The combination fuel cell and hydrogen pump of claim 10 further comprising a controller for applying an electrical load to said electrical contacts of said first and said second electrochemical cells for generating electricity.

12. The combination fuel cell and hydrogen pump of claim 10 further comprising a controller for applying an electrical load to said electrical contacts of said first electrochemical cell for generating electricity, and applying an electrical potential to said electrical contacts of said second electrochemical cell for purifying hydrogen.

13. The combination fuel cell and hydrogen pump of claim 10 wherein said valve comprises a moveable portion comprising said third passageway, said fourth passageway, and said fifth passageway, said moveable portion being moveable between a first position and a second position.

14. The combination fuel cell and hydrogen pump of claim 10 wherein said first and said second electrochemical cells comprise a plurality of electrochemical cells.

15. The combination fuel cell and hydrogen pump of claim 10 wherein said first and said second electrochemical cells comprise a PEM electrochemical cell.
16. A hydrogen fuel infrastructure system comprising
  - a combination fuel cell and ion pump of claim 1;
  - a storage tank for storing purified hydrogen from said combination fuel cell and ion pump; and
  - a reformer for supplying fuel to said combination fuel cell and ion pump.
17. The hydrogen fuel infrastructure system of claim 16 further comprising a battery for storing electrical energy from said combination fuel cell and ion pump.
18. An oxygen infrastructure system comprising
  - a combination fuel cell and ion pump of claim 1;
  - a storage tank for storing purified oxygen from said combination fuel cell and ion pump; and
  - a reformer for supplying fuel to said combination fuel cell and ion pump.
19. The oxygen fuel infrastructure system of claim 18 further comprising a battery for storing electrical energy from said combination fuel cell and ion pump.
20. A hydrogen fuel infrastructure system comprising
  - a combination fuel cell and hydrogen pump of claim 10;
  - a storage tank for storing purified hydrogen from said combination fuel cell and hydrogen pump; and
  - a reformer for supplying fuel to said combination fuel cell and hydrogen pump.

21. The hydrogen fuel infrastructure system of claim 20 further comprising a battery for storing electrical energy from said combination fuel cell and hydrogen pump.
22. A method for generating electricity and purifying at least one of hydrogen and oxygen, the method comprising:
- providing an electrochemical cell comprising an anode inlet for receiving fuel, an anode outlet for exhausting fuel, a cathode inlet for receiving oxidant, and a cathode outlet for exhausting oxidant and at least one of purified hydrogen and purified oxygen; and
  - operating the electrochemical cell to generate electricity and at least one of purify hydrogen and purified oxygen.
23. The method of claim 22 wherein the operating comprises applying an electrical load to the electrochemical cell to generate electricity.
24. The method of claim 22 wherein the operating comprises applying an electrical potential to the electrochemical cell to purify at least one of hydrogen and oxygen.
25. The method of claim 22 wherein the operating comprises blocking oxidant to said cathode inlet and applying an electrical potential to the electrochemical cell to purify hydrogen.
26. The method of claim 22 wherein the operating comprises blocking fuel to said anode inlet and applying an electrical potential to the electrochemical cell to purify oxygen.

27. The method of claim 22 further comprising humidifying the purified hydrogen.
28. The method of claim 22 wherein the electrochemical cell comprises a plurality of electrochemical cells.
29. The method of claim 22 wherein the electrochemical cell comprises a PEM electrochemical cell.
30. The method of claim 22 wherein the electrochemical cell comprises a solid oxide electrochemical cell.